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New records of marine eels (Teleostei: Anguilliformes) from Brazilian waters

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Abstract: Two species of different families belonging to the order Anguilliformes have their ranges extended in the southwestern Atlantic: the chlopsid *Chlopsis dentatus* (Seale, 1917) from Rio de Janeiro and the muraenid *Gymnothorax maderensis* (Johnson, 1862) from Bahia. The new records extend the distribution of these species south along the Brazilian coastline. Morphometric data of the specimens are provided and compared to data from the literature.

Key words: Southwestern Atlantic; Chlopsidae; Muraenidae; *Chlopsis dentatus*; *Gymnothorax maderensis*; range extension

The order Anguilliformes includes more than 800 recognized species in 15 families and about 140 genera. All but three families, Anguillidae, Protanguilidae, and Heterenchelidae, occur in the southwestern Atlantic. About 105 species are reported from Brazilian marine waters, of which the most species-numerous families are Ophichthidae (26 species), Congridae (25 species), and Muraenidae (17 species including *Gymnothorax maderensis*) (Böhlke 1989; Menezes et al. 2003; Melo et al. 2009; Paiva 2011; Bonecker et al. 2014).

Deep-sea research off Brazil has been sparse, but recent exploratory fishing efforts have resulted in several new records, range extensions, and descriptions of new species from the southwestern Atlantic (e.g., Bernardes et al. 2005; Mincarone et al. 2008; Carvalho-Filho et al. 2009, 2010, 2011). Several of these records are of the results of a research project by the Projeto TAMAR (Projeto Tartaruga Marinha, the Brazilian environmental institution that protects and study the sea turtles) team, which aims to evaluate the efficiency of the circle hook in pelagic and bottom longline fisheries (Carvalho-Filho et al. 2009). In this paper, we provide new records for two anguilliform species in the southwestern Atlantic: the chlopsid *Chlopsis dentatus* (Seale, 1917), extending its range southwards to Rio de Janeiro state; and the muraenid *Gymnothorax maderensis* (Johnson, 1862), extending its range to Bahia and Espírito Santo states.

The specimen of *Chlopsis dentatus* was collected in 2010 by a survey team dredging rhodolith banks off the Rio de Janeiro coast. Two specimens of *Gymnothorax maderensis* were collected in 2012 by the deep-sea fishing exploratory crew of the TAMAR Project off Bahia. The specimens were fixed in formalin, preserved in ethanol 70%, and deposited at MZUSP collection. Another seven specimens of *G. maderensis* that we studied were also collected from Bahia, by the Programa de Avaliação do Potencial Sustentável de Recursos Vivos na Zona Econômica Exclusiva (REVIZEE); these are deposited at MNRJ collection. Measurements were taken with a digital caliper to tenths of millimeters (mm); measurements between 150 mm and 300 mm were taken with a manual caliper to the nearest tenth of mm; over 300 mm with a ruler to the nearest tenth of mm. Length of specimens are given in total length (TL) and head length is abbreviated as HL. Institutional abbreviations follow Sabaj-Pérez (2014). Systematics of Anguilliformes follows Betancur et al. (2014).

Family Chlopsidae Rafinesque, 1810

Chlopsis dentatus (Seale, 1917) (Figure 1)

Mottled False Moray (English); Congro-mirim (Brazilian Portuguese) Anguilla moteada, Morena falsa dientona (Spanish).

Morphometric data are given in Table 1. The Chlopsidae are small eels, not longer than 30 cm, with stout to moderately elongate, compressed body with the anus slightly before mid-body. The genus *Chlopsis* is characterized by the absence of pectoral fins; origin of the dorsal fin over or slightly behind gill opening, rictus near posterior margin of eye; anterior nostril tubular, near tip of snout; presence of two series of vomerine teeth; and the lower lip without a downturned flange. *Chlopsis dentatus* is distinguished from all its congeners by its banded mottled color pattern. All other species known to date are bicolored to some degree. *Chlopsis bicolor* Rafinesque, 1810 from the Western Atlantic presents a sharply defined bicolored pattern, and *C. dentatus* also differs by the position of the origin of the

Figure 1. *Chlopsis dentatus*, MZUSP 119852, 85.2 mm TL, with close of the head. Photos by A. Carvalho-Filho.

dorsal fin, distinctly behind the gill opening in *C. bicolor* and slightly behind the gill opening in *C. dentatus*. The only Eastern Atlantic species, *C. olokun* (Robins & Robins, 1966), is a pale, uniformly tan-colored species with white belly, where the bicolored effect is weakly developed. Furthermore, it has the dorsal fin origin located above the gill opening. Our specimen agrees with the diagnostic and specific characters of *C. dentatus* and has the same coloration as described by Seale (1917), Böhlke & Smith (1968), and Smith (1989a). The snout length presented by Smith (1989a) seems to be not accurate (12–14% of head length) when compared to Böhlke & Smith (1968). The identification of the species follows Seale (1917), Robins & Robins (1967), Böhlke and Smith (1968), Blache (1972), Smith (1989a, 1989b, 2016a), Tighe & McCosker (2003), and Bonecker et al. (2014).

Material examined: MZUSP 119852 1, 85.2 mm TL, Campo Peregrino, Station 03 (23°18′ S, 041°17′ W), Bacia de Campos, Campos, Rio de Janeiro, Brazil, collector: F.T.S. Tâmega, depth ca. 100 m, rhodolith bottom, 6 November 2010.

Family Muraenidae Rafinesque, 1815.

Gymnothorax maderensis (Johnson, 1862) (Figure 2).
Sharktooth Moray (English); Moréia-da-madeira, moreão amarelo (Portugal Portuguese); moréia portuguesa (Brazilian Portuguese); morena verde (Spanish).

Morphometric data are given in Table 2. The muraenid body is elongate, muscular, and laterally compressed; dorsal profile of head, above and behind eye, often raised due to strong head muscles; anterior nostril tubular, near snout tip, posterior nostril above or before eye, a simple pore or in a tube. The genus *Gymnothorax* presents the dorsal fin originating above and before the anus, the absence of molarifom teeth, jaws not prominently arched, teeth usually not exposed when mouth is closed; posterior nostril not in the shape of a tube; and gill opening usually the same color of body. *Gymnothorax*

Table 1. Morphometric data for *Chlopsis dentatus,* with source and number of specimens.

Measurements	Present study, 1	Seale (1917), 1	Böhlke & Smith (1968), 6	Range
Proportions				
Total length (mm)	85.2	100.0	95.9–198.5	85.2–198.5
Percentage of total length				
Head length	13.6	13.0	12.0–14.0	12.0–14.0
Pre-anus distance	29.8	31.0	32.0–35.0	29.8–35.0
Pre-dorsal-fin distance	13.0	-----	13.0–16.0	13.0–16.0
Body depth at anus	4.2	-----	4.0–6.8	4.0–6.8
Percentage of head length				
Snout length	24.1	28.4	25.0–27.7	24.1–28.4
Eye diameter	9.5	12.9	9.5–16.0	9.5–16.0
Upper jaw length	38.8	43.5	38.3–41.6	38.3–43.5
Interorbital width	19.0	-----	18.0–23.0	18.0–23.0

Figure 2. *Gymnothorax maderensis*, TAMAR 094, 770.3 mm TL. Insert: close up of a live fish at TAMAR aquarium. Photos by A. Carvalho-Filho.

maderensis can be separated from all other Atlantic congeners, except *Gymnothorax bacalladoi* Bohlke & Brito, 1987, by the presence of serrate edges of the large triangular teeth (Figure 2D); from *G. bacalladoi,* it differs by the uniserial maxillary teeth, usually two branchial pores, and 149–158 vertebrae (versus biserial maxillary teeth, usually one branchial pore and 130–131 vertebrae). Both specimens collected by the TAMAR team from Bahia were covered by a lime-green slime that gives an overall bright lime-green color to live specimens (Figure 2C; see also a photograph of recent collected specimen in Williams et al. 2010). This coating easily disappears from the epidermis of specimens when handled. When this coating is removed, specimens are brownish overall, with some greenish and yellowish tinges on head, light yellow on tail, and minute, numerous, pale dots and/or vermiculation from upper head to tip of tail, more spaced posteriorly. There are

Table 2. Morphometric data for *Gymnothorax maderensis*, with source and number of specimens.

Measurements	Present Study, 9	Johnson (1862), 2	Blache (1967), 2	Böhlke et al. (1989), 14	Range
Proportions					
Total length (mm)	625–940	912–1019	818–905	499–1042	499–1042
Percentage of total length					
Head length	12.4–13.7	12.2	11.6–12.1	10.0 - 12.0	10.0–13.7
Pre-anal-fin distance	51.9–56.3	—	53.8–55.2	50.0–54.0	50.0–56.3
Pre-dorsal-fin distance	11.4–12.4	11.0	11.0–11.1	10.0–11.0	10.0–12.4
Body depth at gill opening	8.6–11.6	8.6	5.4–6.8	6.2–8.7	5.4–11.6
Body depth at anus	4.7– 6.0	—	4.9–5.4	4.2–5.2	4.2– 6.0
Percentage of head length					
Snout length	19.5–22.6	—	17.2–22.8	18.0–22.0	17.2–22.8
Eye diameter	8.5–9.1	6.6	7.1–8.1	6.4–10.0	6.4–10.0
Upper jaw length	38.8–47.2	—	36.4–42.8	37.0–45.0	36.4–47.2
Lower jaw length	40.2–44.7	—	—--	39.0–44.0	39.0–44.7
Interorbital width	14.6–19.4	—	13.8–14.1	13.0–18.0	13.0–19.4

a few dark, short, undulating lines present on underparts of head and anterior trunk. Fins are pale-edged. After preservation, the overall color becomes light tan to yellowish or dark brown, with the pale marks less evident but still well visible. For color variations see GÜNTHER (1870), BLACHE (1967), and BÖHLKE et al. (1989). Some of our measurements widen the range of morphometric proportions of the species (Table 2), as head length, pre-anal-fin and pre-dorsal-fin distances, and depth of body (at gill opening and at anus). We consider these differences in proportions as characteristic of the Brazilian population and the wider ranges herein presented agree with those of other species of the genus, such as *Gymnothorax saxicola* Jordan & Davis, 1891, *G. ocellatus* Agassiz, 1831, and *G. miliaris* (Kaup, 1856), among others (BÖHLKE et al. 1989). The identification of this species follows JOHNSON (1862), GÜNTHER (1870), BLACHE (1967), DOOLEY et al. (1985), BAUCHOT (1986), BÖHLKE et al. (1989), SMITH-VANIZ & JELKS (2014), ROBERTSON & VAN TASSEL (2015), SMITH & MCCOSKER (2015), and SMITH (2016b).

Material examined: MNRJ 18604: 1, 877.2 mm TL, MNRJ 18605: 1, 803.6 mm TL, MNRJ 18961: 1, 883.2 mm TL, MNRJ 18963: 1, 625.0 mm TL, MNRJ 18964: 1, 655.4 mm TL, MNRJ 18981: 1, 940.2 mm TL, and MNRJ 18982: 1, 660.6 mm TL; all from off Bahia, Brazil, collector: Projeto REVIZEE, 1997; TAMAR 097: 1, 770.3 mm TL, and MZUSP 119853: 1, 743.1 mm TL, both from about 10 miles off Praia do Forte, (12°36′96″ S, 037°53′78″ W), Mata de São João, Bahia, Brazil, collector: G. Marcovaldi, depth 200 m, 13 February 2012.

The new records of *Chlopsis dentatus* and *Gymnothorax maderensis* expand the distribution of both species southwards along the Brazilian coast for several thousands of kilometres.

Chlopsis dentatus has a broad distribution, known from the western Indian Ocean (Mozambique and Kenya) and the Atlantic Ocean (SMITH 1989a; BLACHE 1972). In the Western Atlantic, it is known from North Carolina to Florida (USA), Bermuda, the Caribbean (Cuba, Bahamas, Barbados, Curacao, Colombia, Dominican Republic, and the coast of Mexico) and off northern Brazil (SMITH 1989b; MENEZES 2003; vouchers at the NMNH: e.g., 111595, 315438 and 426738, from Cuba, Bermuda and Curacao, respectively; and voucher at the MCZ: Ichthyology 100332, from 03°08′30″ N, 042°52′30″ W, off northern Brazil). In the Eastern Atlantic *C. dentatus* occurs off the coast of Gabon, in the Gulf of Guinea, and around the Canary, Cape Verde and Madeira islands (SMITH 1989a; BLACHE 1972). It is probably sympatric with *C. olokun* (Robins & Robins, 1966), as reported by BLACHE (1972). The Eastern Atlantic distribution is also supported by several vouchers specimens deposited at the BMNH: e.g., BMNH 1994.11.1.477, 1994.11.1.481, and 1994.11.1.482, from Canary, Cape Verde, and Madeira islands, respectively; and vouchers at the MCZ: e.g. Ichthyology 70728, and 70730, from 15°27′ N, 026°12′ W, off Cabo Verde Islands, and 02°54′ S, 008°06′ E, off Gabon. A single specimen collected from western Pacific (Solomon Islands) previously identified as *C. dentatus* by SMITH (1989a) is, in fact, *C. slusserorum* Tighe & McCosker, 2003 (TIGHE et al. 2015).

Figure 3. *Chlopsis dentatus* occurrences in Atlantic Ocean. Based on literature (SMITH 1989a and 1989b; BLACHE 1972; MENEZES 2003) and collections vouchers (BMNH: 1994.11.1.477, 1994.11.1.481, and 1994.11.1.482, from Canary, Cape Verde, and Madeira islands, respectively; MCZ: Ichthyology 100332, from 03°08′30″ N, 042°52′30″ W, off northern Brazil; Ichthyology 70728, and 70730, from 15°27′ N, 026°12′ W, off Cabo Verde Islands, and 02°54′ S, 008°06′ E, off Gabon; NMNH: 111595, 315438 and 426738, from Cuba, Bermuda and Curacao, respectively.Yellow spots, species previously known; red spot, MZUSP 233443 occurrence site.

Figure 4. *Gymnothorax maderensis* occurrences in Atlantic Ocean. Based on literature (DOOLEY et al. 1985; BÖHLKE et al. 1989; WILLIAMS et al. 2010; SMITH-VANIZ & JELKS 2014; ROBERTSON & VAN TASSEL 2015; SMITH & MCCOSKER 2015; MARTINS et al. 2005; OLAVO et al. 2007 and 2011; and PINHEIRO et al. 2015) and examined material. Yellow spots, species previously known records from Eastern and Northern Atlantic; red spots, Brazilian records.

Previous occurrences of *C. dentatus* in Brazilian waters were reported by Bonecker et al. (2014), based only on leptocephali specimens from the same area of the adult recorded here, and by Menezes (2003) based on the above cited MCZ voucher (Ichthyology 100332). Thus, we report the occurrence of an adult *C. dentatus* in the southwestern Atlantic (Figure 3) which, along with the leptocephalus reported by Bonecker et al. (2014), extends the range of the species by ca. 3,300 km southwards along the Brazilian coast, from the previously reported southernmost occurrence locality (off Brazil, MCZ voucher as above).

Gymnothorax maderensis also has a broad range and was previously known in the Eastern Atlantic from Madeira, Cabo Verde, and Canary islands, and Gulf of Guinea (Dooley et al. 1985; Böhlke et al. 1989). In the Western Atlantic it is known from Bermuda, North Carolina to Florida (USA), and the Caribbean region (Cuba, Puerto Rico, Virgin Islands, Anguilla, Antigua, Barbuda, Saba, Bonaire, and Curaçao) (Williams et al. 2010; Smith-Vaniz & Jelks 2014; Robertson & Van Tassel 2015; Smith & McCosker 2015). Records from Brazil are from Bahia and Espírito Santo states, as presented by Martins et al. (2005), Olavo et al. (2007, 2011), and Pinheiro et al. (2015). However, these authors do not present vouchers or details about the records, and thus, our work has significance in being the first vouchered occurrence data for this species in Brazil. Ignoring previous, unvouchered records, the range of this uncommon species in the Western Atlantic is extended by *ca.*6,200 km from the previously reported southernmost occurrence (Bonaire and Curaçao) (Figure 4).

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APPENDIX

Table A1. Literature sources and vouchers for Figure 3, *Chlopsis dentatus* occurrences in Atlantic Ocean.

Source, vouchers	Literature	Vouchers	Locality	Latitude	Longitude
Yellow spots		BMNH 1994.11.1.477	Canary Isl.	27°56′N	37°45′W
Eastern Atlantic	BLACHE 1972; SMITH 1989a.	BMNH 1994.11.1.482	Madeira Isl.	31°23′N	29°49′W
		BMNH 1994.11.1.481	Cape Verde	17°39′N	25°19′W
		MCZ 70728	Cape Verde	15°27′N	26°12′W
		MCZ 70730	Gabon	02°54′S	08°06′E
Northwestern Atlantic	MENEZES 2003; ROBINS & ROBINS 1967; Smith 1989a, 1989b	MCZ 100332	Brazil	03°08′N	42°52′W
		NMNH 111595	Cuba	23°11′N	82°23′W
		NMNH 315438	Bermuda	32°00′N	63°53′W
		NMNH 426738	Curacao	12°06′N	68°53′W
Red spot					
Southwestern Atlantic	BONECKER et al. 2014; this work.	MZUSP 119852	Rio de Janeiro	23°18′S	41°17′W

Table A2. Literature Sources and Vouchers for Figure 4, *Gymnothorax maderensis* occurrences in Atlantic Ocean.

Source, Vouchers	Literature	Vouchers	Locality	Latitude	Longitude
Yellow spots					
Eastern Atlantic	BAUCHOT 1986; BLACHE 1967; BÖHLKE et al. 1989; DOOLEY et al. 1985; GÜNTHER 1870; SMITH & MCCOSKER 2015				
Northwestern Atlantic	BÖHLKE et al. 1989; ROBERTSON & VAN TASSEL 2015; SMITH & MCCOSKER 2015; SMITH-VANIZ & JELKS 2014; WILLIAMS et al. 2010				
Red spots					
Southwestern Atlantic	MARTINS et al. 2010; OLAVO et al. 2007, 2011; PINHEIRO et al. 2015; this work.				
		MNRJ 18604	Bahia	No data	No data
		TAMAR 097	Bahia	12°36′S	37°53′W
		MZUSP 119853	Bahia	12°36′S	37°53′W